ECEN 150 Lab 4 – Series-parallel resistors and potentiometers

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Purposes:

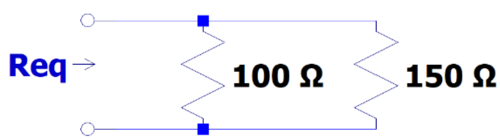
- Experimentally demonstrate the effective resistance of series and parallel resistors
- Demonstrate how a potentiometer can be used to control voltage magnitude
- Become familiar with function generators and oscilloscopes

Procedure:

Part 1. Calculate and measure effective resistances

Step 1: Calculate and measure effective parallel resistance.

- Grab a 100 Ω resistor and a 150 Ω resistor.
- **Calculate** the expected effective resistance for the circuit shown below. **Enter it** in the table.
- **Construct** the parallel resistor circuit shown above using a breadboard. **Measure** the effective resistance and **enter** it in the table. **(**Table: 4 points**)**



Circuit	Calculated value	Measured value
100 Ω || 150 Ω	60 ohms	60 ohms
100 Ω || 150 Ω || short	0 ohms	0 ohms

- Now, **add a wire in parallel** with the two resistors to act as a short. **Measure** the effective resistance and **enter** it in the table. Also, enter the theoretical (calculated) value for this configuration and **enter** it in the table.

Question 1: Explain in your own words: Why is the effective resistance of the two resistors in parallel (without the short) smaller than either of the two individual resistors? What happens to the effective resistance when a wire is placed in parallel? Why? (3 points)

The effective resistance of the two resistors in parallel (without the short) is smaller than either of the two individual resistors because the current gets split up between multiple resistors, so in the math you put 1 over the resistance value making it much smaller.

The effective resistance when a wire is placed in parallel goes to 0 because the current will choose the path of least resistance, and since there's a path with pretty much 0 resistance, it'll go that way and cause a short.

Step 2: Measure the potentiometer resistance.

- Obtain a potentiometer like the one shown to the right. This behaves as a *variable resistor.*
- Measure the **total resistance** of the potentiometer across the **outer two terminals**.
  - *You can insert the potentiometer into a breadboard and use wires to aid with the measurement if it is helpful.

Question 2:

- What is the measured resistance across the outer two terminals? (2 points) 1071 ohms ______
- Does the measured value vary as you turn the knob? (2 points) Yes____________

- Measure the resistance from the **center terminal to an outer terminal**. Vary the knob fully clockwise and fully counterclockwise to find the min and max.

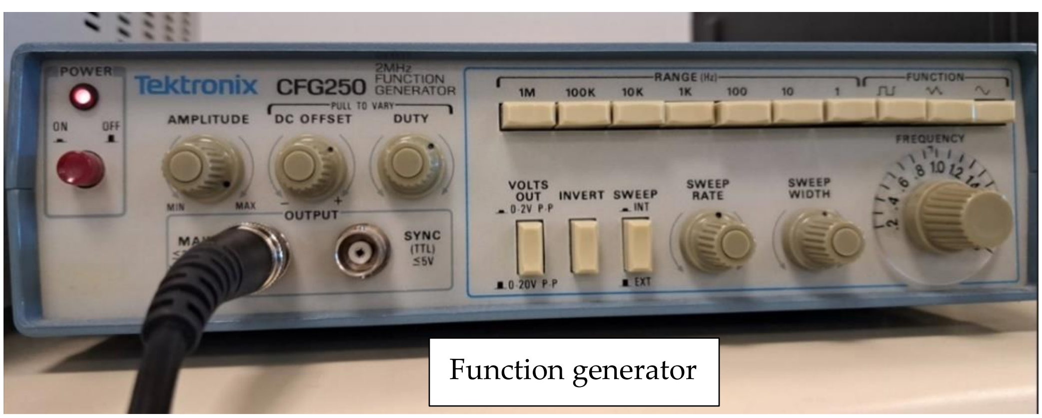
Question 3:

- What is the measured min potentiometer resistance, $R_{pot,min}$? (2 points) 0 ohms ___________
- What is the measured max potentiometer resistance, $R_{pot,max}$? (2 points) 1071 ohms ___________

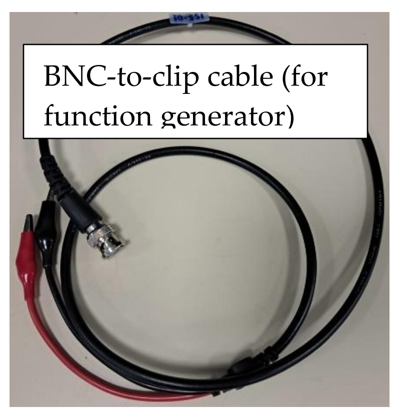
Part 2. Become familiar with the function generator and oscilloscope

Step 1: Configure the function generator.

- A **function generator** ("Fgen") is a voltage source that generates an alternating (ac) voltage signal (like a sinewave). See the photo of the function generator below.
  - Connect a "BNC-to-clip" cable like the one shown here to the "Main output" BNC connector as shown below.



Function generator



BNC-to-clip cable (for function generator)

- Configure the function generator as follows. This will generate a sinewave with frequencies in ranges that our ears can detect once passed through a speaker (later).
  - Select (push) the sinewave function button.
  - Select (push) the "1K" frequency Range (Hz).

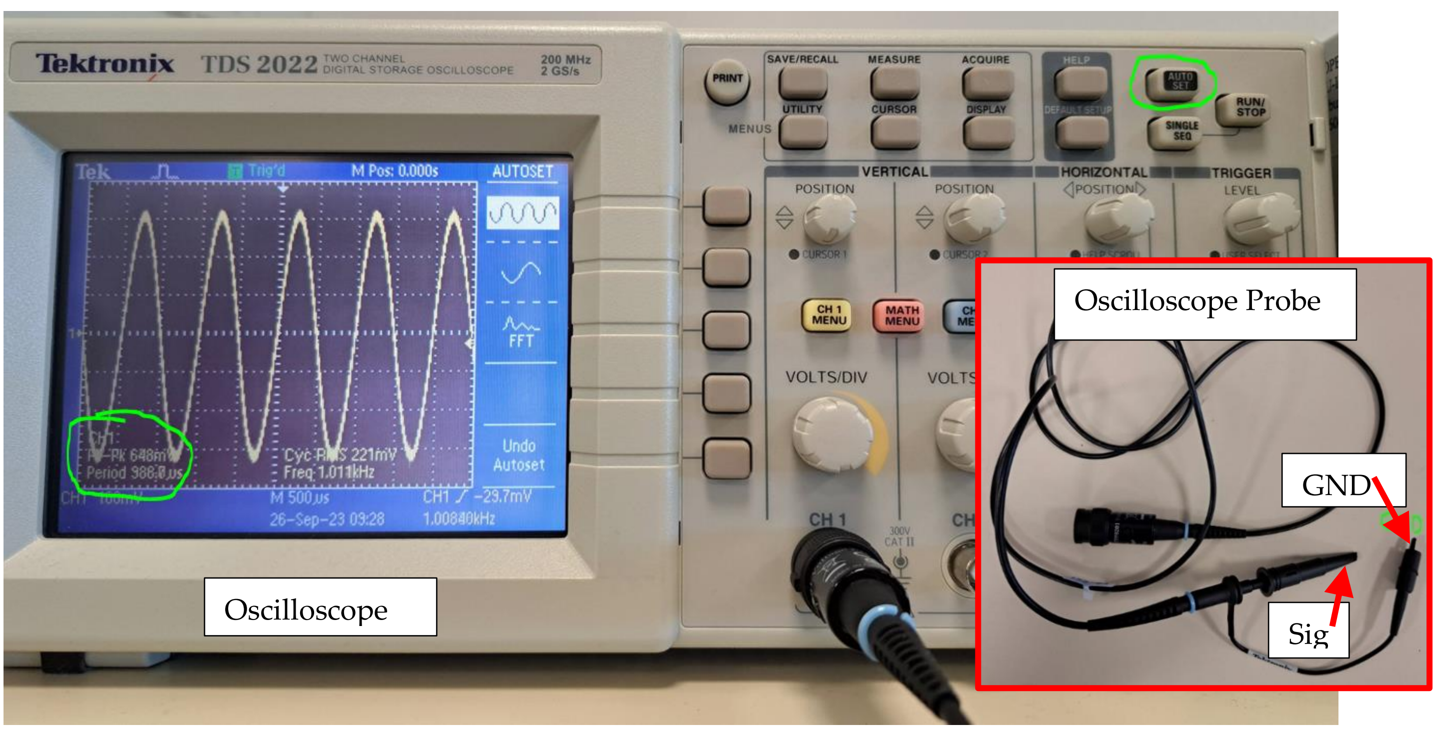
- Ensure the “Volts Out” button is not pressed in, thereby selecting 0-20V “peak-to-peak” magnitude.
- Set the “Frequency” dial somewhere near the middle of the range.
- Turn the “amplitude” knob **all the way to the right** (clockwise). This sets the output to maximum amplitude.
- Make sure the “DC Offset” and “Duty” knobs are pressed in (not pulled out).
- Push the “power” button on.

Step 2: Configure the oscilloscope.

- An **oscilloscope (**or "o-scope" or "scope") is a tool used to measure and visualize time-dependent voltage signals (such as the sinewave we are generating with the function generator).
  - See the photo of the oscilloscope below.
- **Turn on the oscilloscope.**
- Connect the oscilloscope probe to CH 1.
  - Push it on all the way, then twist the round connector clockwise to secure.
  - *If your probe has a slide switch on it, choose "10x" instead of "1x"
- Connect the oscilloscope to the function generator.
  - Connect the scope signal probe to the function generator signal (red) clip.
  - Connect the two ground clips together
  - Push the "auto set" button on the oscilloscope to automatically adjust the settings (see oscilloscope photo; button circled).
- You should now see a sinewave on the screen.

Question 4:

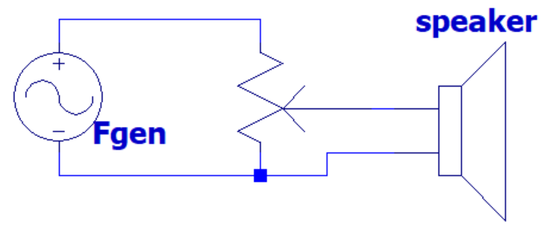
- What is the peak-to-peak voltage of the sinewave being generated by the function generator? This is reported in the bottom left corner of the o-scope screen as "Pk-Pk": 22.6V______________ (2 points)
- (*Pk-Pk should be close to 20 V if you have configured the Fgen and o-scope correctly)



Part 3: Build a potentiometer-controlled speaker circuit

Step 1: Construct the potentiometer speaker circuit.

- Using a breadboard, potentiometer, and speaker, build the circuit illustrated to the right.
- Connect the function generator output to your breadboard circuit as illustrated.
    - *Keep the settings on the function generator as they were in Part 2.
- You should now hear the speaker making an audible tone.



Step 2: Measure the input and output signals with the oscilloscope

- Connect the oscilloscope across the terminals of the speaker to measure the signal being delivered to it.
- Adjust the potentiometer to achieve maximum volume and output magnitude.
    - **Record** the peak-peak value in the table as "speaker input". (*should be 3-3.6 V)
    - Also, **copy** your answer from Question 4 to the table as "Fgen output".

Signal	**Measured pk-pk (V)**
Fgen output signal (from Question 4) (2 pt)	22.6V
Speaker input signal (potentiometer output) (2 pt)	4V

Step 4: Adjust the volume and frequency

- **Vary the potentiometer** and watch the signal amplitude change on the oscilloscope.
    - *Potentiometers are often used to control volume or magnitude, like we did here.

Question 5: The potentiometer creates a voltage divider between the output of the function generator and the input of the speaker. Is the speaker louder when the potentiometer is set to maximum resistance or minimum? **Why**? (Use your knowledge of voltage dividers in your answer. Speakers are louder with larger input voltage) (3 points)

The speaker is louder at the maximum resistance of the potentiometer because the potentiometer and the speaker are in series. So if the resistance of the potentiometer is low, more current will flow through it and less through the speaker. If the resistance through it is high, more current will flow through the speaker and that means there's a greater voltage across the speaker meaning it would be louder.

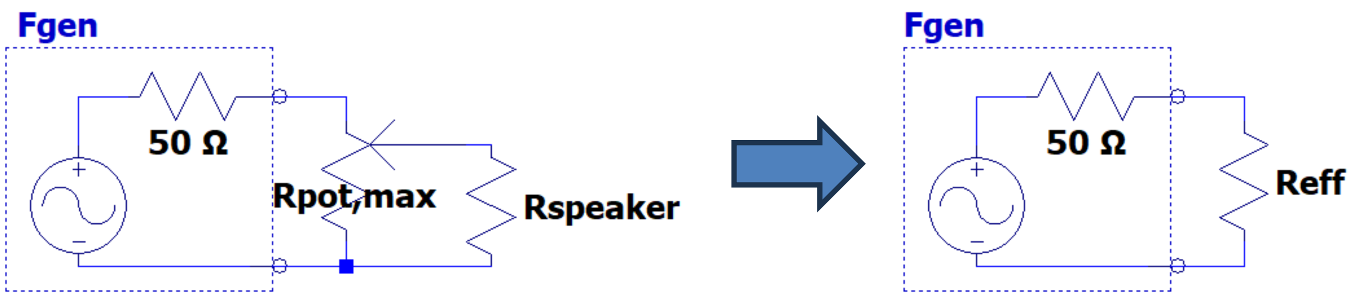
- **Vary the "frequency" knob** on the function generator and watch the signal vary on the oscilloscope.

Question 6: When the tone is **higher** in pitch, does the waveform have a higher frequency or lower frequency? (High frequency means more oscillations per second)

(1 point) Higher frequency__________________

Part 4: Calculate the speaker resistance

- The effective resistances of the circuit you just built, when configured for maximum volume, can be represented as shown below.
  - The function generator has an effective output resistance of 50 Ω (inside the machine).
  - The speaker also has an effective resistance: “Rspeaker”



- For now, treat the Rpot,max and Rspeaker parallel combination as a single resistor called Reff (as shown in the right schematic above).
- Your measured speaker input voltage from the table in Part 3 was measured across “Reff”, which is the output of a voltage divider as shown in the right schematic above.

  Question 7: Using your measured Fgen output and speaker input voltages from Part 3 and the voltage divider equation, what is the value of Reff? **Show your work**. (3 points)

22.6V = i(50ohms) + 4V

18.6V = i(50ohms)

i = 0.372 A

4V / 0.372 A = 10.75 ohms

Reff = 10.75 ohms

- **Question 8:** Now, using your measured Rpot,max value from Question 3 and your calculated Reff value from Question 7, calculate the value of Rspeaker. (*hint: Rspeaker and Rpot,max are in parallel to form Reff). **Show your work**. (3 points)

(1 / 10.75 ohms) = (1 / 1071 ohms) + (1 / Rspeaker)

(1 / 10.75 ohms) - (1 / 1071 ohms) = (1 / Rspeaker)

{1 / [(1 / 10.75 ohms) - (1 / 1071 ohms)]} = Rspeaker

Rspeaker = 10.86 ohms

*****To pass off your circuit, demo it to the TA or instructor and take Lab 4: Quiz 1*****

Part 5. Conclusions statement.

Write a brief conclusions statement that discusses all of the original purposes of the lab. Please use complete sentences and correct grammar to express your thoughts on how you fulfilled the purposes of the lab:

Purposes (repeated):

- Experimentally demonstrate the effective resistance of series and parallel resistors
- Demonstrate how a potentiometer can be used to control voltage magnitude
- Become familiar with function generators and oscilloscopes

1. What happens to effective resistance when multiple resistors are placed in parallel?
2. How do potentiometers behave, and how did we use them today?
3. What do oscilloscopes and function generators do?

Conclusions (15 points):

1. The effective resistance goes down as more resistors are placed in parallel. It's always less than the resistance values of the individual resistors in parallel.
2. Potentiometers are variable resistors, meaning they're resistors that can change the amount of resistance they have. We used a potentiometer to change the amount of resistance in a parallel circuit to allow more or less current to flow through the speaker. If it was just a normal resistor then the speaker would've kept the same amount of voltage across and the same volume.
3. Oscilloscopes are used to measure and graph the waveform of electrical signals in a circuit. We used it to measure the voltage and to see the change in wavelength and frequency as the resistance was changed.
   Function generators generate electrical waveforms with a specific frequency that you can change. We used one today to produce a sin wave and by changing the frequency, it changed the pitch of the sound from the speaker.

Congratulations, you have completed Lab!
You may now submit this document.